Chemistry Quiz
The Gaseous State
Instructor's Version

Answers to Section I (Multiple Choice)

1.	**C**
2.	**C**
3.	**B**
4.	**A**
5.	**A**
6.	**C**
7.	**E**
8.	**B**
9.	**B**
10.	**C**

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Answers to Section II (Free Responses)
Time Limit: You have 30 minutes to complete this section.
Scoring: 60 points total; question 1 is worth 30 points and question 2 is worth 30 points; points for each section are indicated within the question.

1. Kinetic Molecular Theory.

A. The van der Waals equation, shown below, is a variant of the ideal gas law. It can be used to predict molar volumes that more closely match experimental measurements than the values calculated with the ideal gas law. Explain the role of the constants "a" and "b" in the van der Waals equation in terms of the kinetic molecular theory. (15 points)

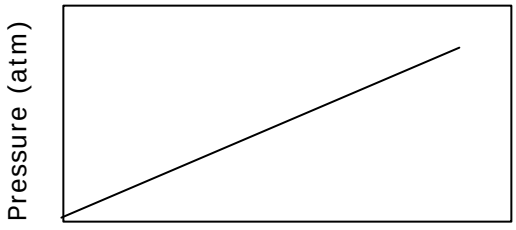
$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$

Answer:
The "a" term adjusts P upward to take into account any inter-particle attractions. These attractions have the net effect of reducing the total force of the collisions of particles with the walls and with each other. This means that the measured P is lower than its true value, and must be adjusted upward to correct for this.

The "b" term adjusts V downward to account for the fact that molecules don't always occupy negligible volume relative to the container.

B. A steel drum is filled with air, sealed, and put over a flame. The volume of gas did not change because of the strength of the container. What is the relationship between pressure and temperature? Write an equation that would represent this relationship. Sketch a graph that would be produced from P vs T. Use the kinetic molecular theory to justify what happens to pressure when temperature increases at a constant volume. (15 points)

Answer:
Given the ideal gas law, PV = nRT, when V and number of moles of gas are held constant, P will be directly proportional to V. A plot of P vs. T will have a linear, positive slope and an intercept of zero when T is in kelvins:



As T increases, the kinetic energy of the gas particles increases. Since there is no change in mass, and since KE = 1/2 mv^2, the increase in kinetic energy is seen as an increase in particle velocity. This in turn increases the force of the particles' collisions with the walls and with each other, so P goes up.

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2. Laboratory analysis.

A. 2.00 g of an unknown volatile liquid was placed in a flask with a total volume of 265.0 mL. It was covered with only a pinhole to allow pressure to equilibrate with the outside. The temperature was raised to 100.00°C by placing it in a constant temperature water bath. At this temperature, it was found that only 0.581 g of the liquid substance remained in the flask. A barometer in the lab showed the pressure to be 752 mmHg. What is the molar mass of the unknown liquid? (15 points)

Answer:
Moles vaporized = n = PV/RT = (752/760)(0.265 L)/(0.0821)(373.15 K) = 8.56 x 10^{-3} Mass of substance vaporized = 2.00 g initially – 0.581 g remaining = 1.419 g
Molar mass = 1.419 g/8.56 x 10^{-3} moles = 166 g/mol

B. A 7.65 g sample of potassium chlorate, $KClO_3$, was heated to decompose all the oxygen. It was found that 2.25 L of oxygen was collected over water at 25.00°C and 1.00 atm of pressure. The vapor pressure of water at that temperature is 23.8 mmHg. How many moles of oxygen were collected? (15 points)

Answer:
$P(O_2)$ = P(total) – $P(H_2O)$ = 760 mmHg – 23.8 mmHg = 736.2 mmHg (treat the 760 as exact)
Moles O_2 = n = PV/RT = (736.2/760)(2.25 L)/(0.0821)(298.15 K) = 8.90 x 10^{-2}

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